UNIVERSITY OF HAWAII

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Environmental Center

Office of the Director

KAIMU BEACH PLAN

Statement for the Corps of Engineers
Public Hearing 9 March 1972

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Summary

The Corps of Engineers has proposed certain alterations to the beach and bay at Kaimu, Hawaii. In the plan recommended by the Corps, the beach would be widened and protected by a low offshore breakwater. In a basic plan discussed by the Corps, the beach would be widened and its erosion compensated by subsequent sand replenishment. The recommended plan would provide much better opportunities for swimming than exist at present. It is assumed that a final commitment to the proposed project has not yet been made, and that further examination of detriments as well as benefits, associated with the proposed plans and is appropriate, together with the identification of additional alternatives warranting examination.

The following activities at Kaimu are considered to have present or potential value:

a. Swimming

b. Surfing

c. Fishing

d. Such recreational uses of the beach as picnicking, sunbathing, surf watching

e. Enjoyment of scenic beauty

f. Enjoyment of visual novelty (of the black sand)

g. Enjoyment of such traditional, historical, and scientific significance as is attached to the beach and coast.

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The Corps Report on the project appears to disregard certain losses in value that will result from the adoption of the recommended plan and/or identified alternatives; to use, in its economic cost/benefit comparisons between the recommended plan and identified alternatives, some unsupported and questionable estimates; and to fail to consider some apparently feasible alternatives.

a. Swimming is correctly identified as a major benefit to result from the recommended plan. Swimming, with the basic plan as at present, will be of small, though not zero value.

b. Surfing is identified as an activity that would be retained with the basic plan but not with the recommended plan. However, the cost/benefit analyses show no cost associated with the loss. We believe the loss would be significant. Present surfing use is light but increasing, and the scarcity of surfing sites on the island of Hawaii adds to the value of those at Kaimu.

c. Fishing is identified as an activity that would be retained with the basic plan but not with the recommended plan. However, the cost/benefit analyses show no cost associated with the loss. So far as we know the loss will not be large.

d. Additional space will be created for on-the-beach recreation by both basic and recommended plans. However the recreational utility of this space will not be equal to that of the present beach. The sand proposed for use will be sharp-edged and harsh. Even disregarding this serious limitation, the benefits are exaggerated by including already existing beach area on which the benefit is estimated. Recent measurements suggest that the beach is receding at approximately half the rate estimated in the report, the width of the beach is decreasing even less rapidly, and both theory and measurements suggest an approach toward stability as the beach recedes.

e. There is little question that the beach created by the basic plan may with care be made beautiful. To many, however, the beauty of the scene will be marred by the breakwater proposed under the recommended plan to extend completely across the bay. There may also be significant loss of beauty associated with the opening of the breakwater-rock quarry.

f. With either plan, if sand from the proposed source is used, the famous jet black sand beach will be lost just as surely as if it is eroded away. The sand, as mixed and laid on the beach will, we believe, be brownish. To some this will be not only a loss of novelty but a loss of beauty. These losses are not mentioned in the report on the project.

g. The surfing at Kaimu was noted in tradition not only as a participant sport but as a spectator sport. Little significance seems generally to be given to this tradition, and none in the report, but it remains a potential bonus to the normal value of the surfing that could be capitalized if it is not lost as it would be under the recommended plan. The report recognizes the source of the Kaimu beach sand in the 1750 lava fragmented when it hit the sea, but does not recognize the significance of the beach as the best-known example of the type of evanescent beach formed in this manner. This significance would be lost if an artificial beach were created at the site. If the lava ridge from which the breakwater rock will be quarried is that in which is located the famous cove of refuge, there will be an additional loss of tradition.

The importance of the swimming opportunities that would be provided by the recommended plan would perhaps be sufficient to offset all of the detriments if no alternative means were available to provide for swimming. There is, however, no evidence that alternatives have been examined, other than those identified in the report, and suggest that swimming beaches might be created, without most of the detriments we have discussed, at other natural coves along the southeast coast of Puna or in coves artificially excavated in low land, and even that a swimming beach could be created at Kaimu and protected without the loss of the surfing by less conventional methods than a rock breakwater.

Introduction

This statement concerns the environmental effects of plans to restore Kaimu Beach, and possibly to protect it from erosion by a low breakwater. The particular plans and rationale for restoration and protection of Kaimu Beach to which the statement has reference are those described in a Detailed Project Report entitled "Kaimu Beach, Island of Hawaii" issued by the U.S. Army Engineer Division, Pacific Ocean in September 1971 (USCE, 1971). We have also had available to us discussions of the advantages and disadvantages in a briefing folder, "Kaimu Beach Erosion Control Project", assembled by the Corps of Engineers in February 1972.

This statement represents an expansion and documentation of a summary by Cox and Healy and a separate statement by Bretschneider presented at the public hearing on the proposed Kaimu Beach project held 9 March 1972 in Hilo. It is our understanding that this hearing was intended to permit the U.S. Army Corps of Engineers to present its proposals for the enlargement and protection of Kaimu Beach, and for those favoring and opposed to the plan to present their views. We assume that no final commitment has been made to the plans presented by the Corps.

In the preparation of our statement the following members of the Environmental Center have been consulted: from the College of Arts and Sciences: A.H. Banner, Professor of Zoology, Samuel Elbert, Professor of Pacific Languages and Linguistics, Gordon A. Macdonald, Professor of Geology, and Ralph M. Moberly, Professor of Geology; from the College of Engineering: John T. O'Brien, Director, Look Laboratory; and from the Hilo College: James Juvik, Assistant Professor of Geography.

Directly or indirectly we have also become aware of the views of a number of persons, far too many to identify. However, we should acknowledge that the project has been discussed with us by John M. Kelly, Jr., spokesman for Save Our Surf, an organization which opposes the recommended plan.

Although we have tried to evaluate objectively the information available to us from our consultants, the conclusions we draw do not necessarily represent their views. Our statement does not represent the institutional position of the University of Hawaii.

Purpose of Corps of Engineers Study

The purpose and extent of the study of the Corps of Engineers are expressed in their report as follows:

> "The general purpose of this study is to investigate the overall problem of beach erosion at Kaimu Beach on the island

of Hawaii, to propose the best means of reducing or preventing further destruction of the beach and the best means of construction that assures an attractive beach area. The specific objectives of this study are to analyze the problem conditions to the degree necessary to determine the most practicable engineering methods for halting or restricting continued erosion without marring the beauty of this rare black sand beach, to develop appropriate project plans therefor, to establish the economic feasibility of Federal assistance, and to identify the extent of Federal and local cost sharing that would be warranted in accordance with public law. This report pertains to a study area of 1.5 miles of coastline with detailed analysis being devoted to approximately 1,600 feet of shoreline within that distance."

The "History of the Kaimu Beach Erosion Control Project" in the Corps briefing folder indicates that the 1966 request from the Mayor of the County of Hawaii to the Corps for their study stemmed from concerns expressed by the Puna Lions Club, including a concern for "creating a swimming area free from erosion and free from contamination resulting from natural hazards". This concern was officially reflected by the County in June 1970 in its choice of the one among three alternative plans then submitted by the Corps, including construction of a submerged breakwater across the bay, "because the breakwater would create a much-needed safe swimming facility in the Puna District and this facility will greatly enhance our land acquisition and subsequent park development plans in the vicinity of Kaimu Beach".

Subsequent entries in the "History" indicate additional concerns initially expressed by the Corps or brought to the attention of the Corps; relating to the ecology of the area, archaeological and historic sites, adverse effects that might result from the proposed use of Kaakepa Cone material for beach fill, influences of faulting or submergence, influence of tsunamis, influence of wind erosion, impairment of surfing, impairment of fishing, impairment of beauty resulting from increasing the breakwater height in a plan later recommended, and other aspects.

Premises

We assume that, at least until a final commitment is made, it is pertinent to examine whether all detriments as well as benefits associated with the project have been identified and reasonably assessed, including non-material detriments and benefits as well as economic ones, and that all reasonable alternatives for providing benefits have been identified and their detriments assessed, so that it can reasonably be assured that the net benefits or the cost/benefit ratio is largest in the case of the plan to be adopted.

We consider that the activites and opportunities at Kaimu that have value or potential value include the following:

a. Swimming
b. Surfing
c. Fishing
d. Such recreational uses of the beach as picnicking, sunbathing, surf watching
e. Enjoyment of scenic beauty
f. Enjoyment of visual novelty (of the black sand)
g. Enjoyment of such traditional, historical, and scientific significance as is attached to the beach and coast.

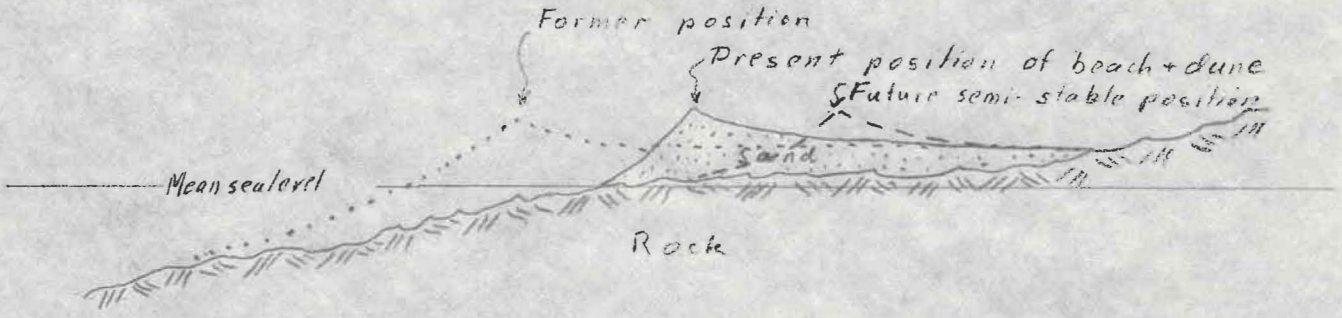
Setting, description, origin, and history

The setting and description of Kaimu Beach are well described in the Corps of Engineers report and two reports of the Hawaii Institute of Geophysics cited there (Moberly 1963, Moberly and Chamberlain 1964). The Corps report also observes (p. 3) that the beach was formed by the long-shore drift and deposition of black glass sand formed by steam explosions where a lava flow entered the ocean and identifies the flow that was probably the specific source of the Kaimu sand as that which was erupted about 1750 and which forms the present coast northeast of Kaimu Bay. The implications of this observation are, however, not explored in the report.

Beaches formed in the manner of Kaimu Beach have been formed repeatedly during the volcanic construction of the Island of Hawaii. One is now forming just northeast of Waipahu point through the accumulation of sand derived from the 1955 lava flow where it entered the ocean. However, such beaches are by nature evanescent.

Sand is lost continuously from all beaches by attrition, long-shore transport, offshore transport to deep water, or wind transport inland. The stability of a sand beach depends on the continuing supply of and by natural stream or long-shore transport or by artificial processes. When the material comminuted by the steam explosions is exhausted, the supply of sand to beaches like that at Kaimu is ended, and the natural erosion and transportation processes must inevitably result in the recession and eventual loss of the beach. The active lives of most beaches of the Kaimu type may be limited to a few hundred years even if they are not buried by lava flows subsequent to those providing the source of their sand.

The original, natural source material for the Kaimu beach was exhausted some time in the past. Hence the long-term retreat of the beach was naturally to be expected. The rock beneath the sand at Kaimu has, however, become exposed first at the toe of the beach and in ridges now protruding through the beach face. With further recession, more rock will be exposed, providing greater protection to the remaining sand so that the rate of recession will be slowed. The upper part of the beach and segments of the beach face may, then, be preserved in a naturally semi-stable fashion for a long time, as indicated in the figure below.



Like all beaches, those of the Kaimu type are subject to normal cycles of advance and retreat depending on seasonal and other changes in wave conditions (as shown by the measurements of Moberly and Chamberlain, 1964) and also to the effects of rare events such as uncommon storms, tsunamis,

and crustal elevation or depression.

The Puna coast of Hawaii is especially unstable. The Kaimu-Kalapana area is within a graben bounded on the north by the eastward extension of the Hilina fault system on the southern flank of Kilauea and on the south by a fault that lies along the low lava-rock ridge south of Kalapana (in which the Cave of Refuge is located). The floor of the graben sank during the great earthquake swarm of 1868, allowing sea water to flood the old churchyard at Kalapana. The precise amount of sinking at Kaimu is unknown, but Coan (1869) records sinking of 4 to 6 feet in the general Kalapana area. In addition, the island of Hawaii as a whole is sinking, independently of the graben faulting. Abundant evidence of this, in the form of submerged tree molds and old fish-pond walls, is found along the Puna coast, but the rate of sinking there cannot be determined because of lack of dates for the molds or the walls. At Honaunau, on the Kona coast, the rate of sinking is approximately 1 foot per century (Apple and Macdonald, 1966). At Hilo, gage records indicate a sinking rate of about 19 inches per century (Moore, 1971). The general rate of sinking of the Puna coast is probably about the same. That is, since 1900 the coast of the island of Hawaii has been submerged by about 0.7 foot. The effects of the local and general submergence on the beach are uncertain, but presumably the greater exposure resulting from the submergence of off-shore reefs would result in an increase in the rates of erosion and hence the rate of recession.

At Kaimu, during the tsunami of April 1, 1946, water reached heights of 18 to 20 feet on shore, destroying houses, undercutting the highway, and stripping away soil to a depth of 1 foot 50 feet inland (Shepard, Macdonald, and Cox, 1950, p. 440). The condition of the beach before the tsunami is not known but Cox and Macdonald recall that the beach front was very steep and the roots of coconut trees growing on it were exposed a few days later, suggesting active retreat at the time. Whether this resulted from the tsunami or not is unclear. Other tsunamis may be assumed to have had some effect on the beach, notably those arriving from Chile in 1819, 1835, 1837, 1868, 1877, 1922, and 1960 and particular one generated just off the Puna-Kau coast in April 1868 (Pararas-Carayannis, 1969). The only Chile tsunami for which a measurement was recorded at Kaimu was that of 1960 which had a runup there of about 12 feet. No estimate of the runup of the 1968 local tsunami was made at Kaimu, but estimates for the Puna-Kau coast in general ranged from about 25 to 60 feet.

The immediate effects of those of the tsunamis that had high runups at Kaimu were probably beach recessions but the extent of these recessions is unknown, and they may have been more or less compensated by subsequent advances as are the seasonal recessions (Moberly 1963 and USCE 1971, plate A-9).

The Corps Report presents evidence that Kaimu beach has receded as much as 400 feet in something less than three-quarters of a century. Information in an appendix (Appendix A, p. 5 and plate 7) indicates the position of the shore in 1900 and 1938 and the position existing presumably sometime in 1971. The changes in shore position are consistent with a recession averaging between 200 and 300 feet with a maximum of about 400 feet. However, the particular lines of the shore whose positions are indicated are not identified, and the seasons of the year during which the surveys were conducted are not indicated. To confuse the problem the discussion of shoreline changes in the report (pp. 8-9) mentions surveys only in 1915 and 1968, and the report presents conflicting estimates of the average historical recession: 275 feet since 1900 (p. 3), 200 feet from 1915 to 1968 (p. 8) and 200 feet since

1900 (p. 9). The current average recession is estimated at 4 feet.

Possible differences in the seasons of the surveys introduce uncertainties of as much as 30 feet, possible differences in identification of shorelines introduce an uncertainty of as much as 50 or 60 feet (mllw to the *kahakai*, the "mark of the sea"), and the length of the history seems uncertain within the range from 53 years (1915 to 1968) to 71 years (1900 to 1971). Average rates of recession over the history of measurement might then conceivably range from less than 2 ft/yr ((200-80)/71 = 1.7) to more than 7 ft/yr ((275+ 80)/53 = 6.7). The present average rate of recession is estimated in the report (p. 3) at 4 ft/yr, though no basis for the estimate is prescribed. Comparison of the results of repeated surveys in 1962 and 1963 with the results of a recent resurvey by Moberly of the same profile indicates a net recession of 15 ± 2 ft. from the summer of 1963 to the summer of 1971, an average of slightly less than 2 ft /yr.

The volume of sand lost from the beach is estimated in the report (p. 9) at 140,000 cu. yds., and the average loss at 2000 cu. yds./yr but these estimates seem subject to the same kinds of uncertainty as those pertaining to the estimates of recession.

The ranges of uncertainty could certainly be reduced by reference to the original surveys on which the estimates are based, but these are not cited in the report. We would not like to leave the impression that a high degree of precision in the estimates is expectable, or that estimates of the long-term and recent rates of recession and loss of sand would have much significance, much less that possible future effects could be estimated closely if the estimates of past effects were precise. However, it would seem advisable to reduce the range of uncertainty as much as possible by review of the historic record.

The relative importance of the contributions to the loss of sand by long-shore transport from the beach, offshore transport to deep water, and wind transport inland, and direct reduction in volume by attrition of the sand grains, is of some interest in relation to possible means for controlling the recession of the beach. There is, unfortunately, little information available for the evaluation of these processes.

The Corps briefing folder indicates that the landward movement of the beach-dune crest has been held by some to indicate the effectiveness of wind erosion and transport. There is indeed clear evidence of the landward movement of the beach crest in the presence, on coconut trees now being undermined on the beach face, of root systems at two levels. The original system was developed during the early part of the lives of the trees just below the original lowland ground level behind the beach-dune crest. An adventitious system a few feet higher was developed when the bases of the trees were buried by the landward moving beach-dune crest. Wind transport is certainly an important agent in the landward movement of the crest, but storm waves also contribute. A recent informal communication from the Corps indicates that the grain size distribution of the sand in the backshore area is the same as that in the foreshore area. This would not be the case if the sand in the backshore area had been deposited by wind alone. The available evidence suggests that the material carried landward is mainly deposited in the beach-dune crest, which has not increased in volume but merely shifted in position. In other words these landward transport processes have merely permitted the landward movement of the beach-dune crest to keep up with the landward erosion of the beach face and cannot account for the loss of material

from the face.

The presence of the extensive black sand dunes at Kalapana, half a mile from Kaimu in the direction of long-shore transport expected from directions of approach of the prevailing waves, suggests that landward wind transport of the sand removed from the beach face has been important, but only after wave erosion of the beach face and long-shore transport. The sand must be reduced in size by attrition to allow it to be picked up by the wind, and some of the size reduction may occur on the beach itself and be responsible for loss of stability in the beach.

The direct reduction of sand volume by attrition and the offshore transport of sand could be evaluated, but not precisely, and only by extensive long-term study.

A contribution to the recession of Kaimu beach not noted in the Corps Report is sand mining. In the past the private persons and the County of Hawaii have used considerable amounts of sand from the beach on roads, in concrete, and in filters, and undoubtedly small amounts of material were removed from the beach in Hawaiian times for house platforms and perhaps heiaus. Sand is also removed for sale in tourist shops on Hawaii and in Honolulu and removed by visitors to the beach, to whom some tour drivers supply plastic bags for the purpose, but the amounts so removed are probably insignificant in comparison with other losses.

Coastal uses

In Hawaiian times there was a village at Kaimu which undoubtedly used the waters for fishing, bathing, and surfing. The surfing is well documented. In the story of Halemano, the heroine is captured while surfing at Kaimu:

> *"'O ia kahi he'e nalu mau i na wa a pau loa"*
> "This was a surfing place continuously and at all times" (Elbert 1959)

A *mele* honoring King Lunaliho (1835-74) indicates that surfing was not only a participant sport but a spectator sport (Elbert and Mahoe, 1970)

'Auhea 'o ka Lani la?	Where is the royal chief?
Aia i ka he'e nalu...	There, surfing...
A pae a'e a i Kaimū la,	Landing at Kaimū
Ho'omū nā kānaka...	Where the people gather...

This documentation confirms the origin of the place name assigned by Pukui and Elbert (1966): "Kai-mu, Land division, Puna, Hawaii, noted for its surf. Lit. gathering (at the) sea (to watch surfing)."

With the westernization of Hawaii and the decrease of population on the southeast coast of the Puna district, the use of the coastal waters undoubtedly decreased. The Corps Report (p. 14) recognizes that there are three surfing sites at Kaimu but indicates that their popularity could not be established. It recognizes a report that there is an akule fishing ground at Kaimu but indicates that this could not be verified. It fails to mention swimming except as a future possibility if a breakwater is constructed.

With the great resurgence of board surfing in Hawaii, use of the surfing sites at Kaimu has again increased. Two of the three sites are identified by Finney and Houston (1966). In its inventory and evaluation of recreation

resources, the State Comprehensive Outdoor Recreation Plan (SCORP) (Dept. Planning & Econ. Dev., 1971, App. C) the surfing at Kaimu is given a rating of 25 among ratings ranging from 18 to 26 for surfing sites around all the islands. The meager statistics available on use of the Kaimu surfing site, which are presented in the Corps Briefing Folder under "Argument, project would destroy surfing" (also Bretschneider et. al. 1971), should be taken as an indication of a rapid increase in use rather than as evidence of low popularity. It should be noted that the density of surfing sites on the island of Hawaii is far lower than on other islands, 0.6 per mile of coast as compared with 2.9 for Oahu, for example (John Kelly, personal communication). Future increases in the use of the surfing sites at Kaimu appears limited principally by the capacity of the sites. There would appear to be more justification to increasing the number of surf sites on the Puna coast than to destruction of those few surf sites already in existence.

Kenji Ego of the Fish and Game Division of the State Department of Land and Natural Resources has provided us data on catches of akule (including halulu, the young akule) as reported to the Fisheries Branch of the Division. The following statistics pertain to the Puna coast and the total for the island of Hawaii:

Coast segment	1967	1968	1969	1970
Leleiwi Pt. to Kalapana	564	3,203	8,189	3,638
Kalapana to Punaluu	260	356	3,424	1,280
Hawaii Island total	21,368	50,698	33,883	66,208

The catches are mostly made by handline offshore though some are made by seine net in shallow water. The primary reason for the small fraction of the total island catch represented by the catch on the Puna coast is the rough-water exposure on that coast. We know of no statistics on fishing pertinent specifically to Kaimu, as distinct from the general coastline, but have seen photographic evidence of the presence of a school of akule suggesting at least a fishing potential.

The beach at Kaimu is occasionally used for swimming, although much of the time the waters are not safe for inexperienced swimmers. With normal wave conditions there is generally a pronounced rip current in the bay, and at times its seaward speed is very high (Bretschneider et. al. 1971). The hazards of swimming at the beach have beem increased since the rock base was exposed along part of the beach. It should be noted that swimming would have a high value, if it could be made safe, because of the scarcity of good swimming beaches on the island of Hawaii.

The recreational use of the land portion of the beach celebrated in the place name also undoubtedly decreased in the 1800's, but the beach became famous then for its beauty and the novelty of its black sand. It has always been a popular picnic spot for local residents, and its fame led to its incorporation in tourist itineraries with the inception of tourism on Hawaii and still leads to increasing numbers of tourist visits.

We pointed out in the historical section of this statement that the natural Kaimu Beach was an evanescent feature. It should be recognized that this famous natural beach could not have been preserved indefinately in its prime condition and that it can never be recreated in its natural condition. What is proposed in the Corps of Engineers project is to create by artificial means a new beach, inevitably different in character from the original natural beach, and to provide means either to protect it from erosion by a breakwater or to offset the erosion by continuous replenishment if no break-

water is built.

A recent memorandum from the State Natural Area Reserves System Commission (Appendix /) indicates that the Commission considers Kaimu Beach "a geologic feature meriting intensive consideration for protection of its natural state from any sort of development". The commission therefore requests "that no breakwater construction be authorized until the Commission has concluded its survey of the State's geologic features".

Restoration is a misnomer for the proposal. The new beach would be a facsimile serving some of the uses of the old beach with possibly some new ones as well, preferably a facsimile to which some of the tradition and beauty of the original beach may be attached. With care the beach could be shaped to resemble the form of the original natural beach at sometime in its past history. Its structure will not be the same as that of the original, because its processes of creation would not be the same, but the differences would only be of technical interest. Of more general concern will be the differences between the materials in the new beach and those in the old. The sand deposited on the natural beach was very nearly pure black. That which will come from Puu Kaakepa is in part red and brown, and the mineable screened mixture will probably be brownish. The sand originally forming on the natural beach had been rounded in long-shore transport from its source in the 1750 flow. That which will be mined and screened from Puu Kaapepa will be angular and harsh underfoot. After a time the new sand on the lower part of the beach will be rounded through being rolled by the waves but the sand on the upper part of the beach will remain harsh almost indefinately, although it may become covered by sand transported from the lower part of the beach.

Recommended plan, identified alternatives, and effects

The plan recommended by the Corps of Engineers for the restoration and protection of Kaimu beach consists of placing 40,000 cu. yds. of sand on the existing beach, covering it by at least 3 ft. at the high water level, and construction of a breakwater about 300 ft. seaward from the beach, extending completely across the bay with a crest height 2.5 ft. above mean lower low water (mllw).

The top of the new beach at 7 ft. above mllw would apparently be about 15 ft. wide (Profile on plate 1), and the slope of the beach face would be reduced to 1 on 10 so that at lower elevations the width of fill would be greater. The area according to the Corps Report would be 100,000 sq. ft., but this estimate appears to include the area of the present beach. The added area above high water, it appears, would be about 30,000 ft. The actual increase in width at the top of the berm appears to be about 15 ft. and at high water about 20 ft.

The sand for the new beach would be produced by screening from the cinders and ash of Puu Kaakepa, in which a quarry has already been opened. Stone for the breakwater would come from a lava flow ridge at Kalapana not yet quarried or alternatively from quarries that were used in the construction of the Chain of Craters highway. The Corps Report does not comment on the esthetic effects of opening a quarry in the ridge at Kalapana. If this ridge is that in which the "Cave of Refuge" is located, the esthetic effects might be very detrimental.

Three alternative plans are discussed in the report: a basic plan con-

sisting in the restoration of the beach alone without providing protection, and two alternate plans including breakwaters with crests at mllw instead of 2.5 ft. above, the breakwater in the first alternative being restricted to a length of 450 ft. providing protection only to the southwest part of the beach.

Apart from the color and harshness of its sand, the beach proposed in the basic plan discussed by the Corps would constitute a reasonable facsimile of the natural beach. The first and second alternative plans and particularly the recommended plan, would provide additional benefits in increased opportunities for swimming, particularly for the less hardy swimmers. However, these benefits would be at least partially offset by the loss of surfing opportunities, the loss of surf-watching opportunities, and the visual impact of the breakwater.

The fame of the black sand beach adds an extra increment of value to the beauty of the beach, which would be lost if the color of the beach were changed. Similarly traditions of surfing and surf-watching could add extra increments of value to the surf and the beach, which could never be captured if the surf sites were destroyed.

The effectiveness of the proposed breakwater schemes in controlling the recession of the proposed new beach depends on the reduction of wave energy on the beach effected by the breakwater, on the characteristics of the beach including its shape, the size and compaction of the sand, and mode of movement. The uncertainty in the estimate of the natural rate of recession and the uncertainty of the relative importance of the various modes of sand movement have already been discussed.

Costs and benefits

The total annual costs, benefits, and benefit/cost ratios of the several plans, estimated by the Corps may be summarized as follows:

Annual cost	Basic Plan	Alternatives 1	Alternatives 2	Recommended Plan
Interest and amortization	$24,000	$34,000	$51,000	$64,000
Maintenance	15,000	14,000	12,000	9,000
Total	$39,000	$48,000	$63,000	$73,000
Annual benefits				
Preventing loss of coconut trees	5,000	5,000	5,000	5,000
Tourist visits	131,000	131,000	131,000	131,000
Beach park use	0	26,000	86,000	172,000
Total	136,000	162,000	222,000	308,000
Cost/benefit ratio	3.5	3.4	3.5	4.2

The maintenance cost in the basic plan is that associated with the replenishment of sand, assumed to be the same as the present estimated rate of loss, 2000 cu. yds./yr. The uncertainty of this estimate has been discussed above. In alternative 1, alternative 2, and the recommended plan, the rates of replenishment required are estimated at 90%, 60 %, and 30%, respectively, of the rate needed without breakwater protection, but the maintenance costs include breakwater replacement costs in addition to those of sand replenishment.

The benefits from tourist visits are based on a projection of such visits and a valuation of 25 cents per visit. These benefits are assumed to start from 1972 on the basis that the beach has already become so narrow that no further tourist visits will occur (p. 17). This assumption seems erroneous. No evidence has been presented that the beach is being narrowed. It is retreating, but the rate of retreat of the lower part of the beach is matched by a retreat of the front of the coconut plantation at the top of the beach so that the beach width remains essentially unchanged. The rate of beach retreat will probably be slowed as more rock is exposed at the toe of the beach, as pointed out in the section on the history of the beach. Although the beach will become less attractive as more rock shows, the overall increase in tourism on Hawaii may well result in an increase in the rate of tourist visits even if the beach is not widened. The benefit should properly be calculated as that due from the increase in visitation due to the added attractiveness of the widened beach rather than that due to total visitation. The proper benefits may be much lower than those shown in the report.

The benefits from beach park use, which includes swimming, are based, for the recommended plan on: the total beach area; a minimum area of 75 sq. ft./user; estimated peak day uses at twice the instantaneous use; non-peak-day uses at 1/3 peak-day uses, approximately 60% peak-use days, 30% non-peak-use days, and 10% no-use days; and a gradual increase to full utilization by 2010. The benefits for the first and second alternatives are estimated at 15% and 50%, respectively, of the benefit for the recommended plan, on the grounds that the protection for swimming of the lower breakwater would be less and the protection in the case of the short breakwater still less. No benefit for beach park use is granted by the Corps for the basic plan without a breakwater.

The differentials in these estimates of benefits are subject to serious challenge on several grounds. First, they do not recognize any benefits in non-swimming uses of the beach, such as sunbathing and picnicking, as the beach now exists and as it would be widened under the basic plan. Second they do not recognize that, even rocky and exposed as the beach is now, there is some swimming, and there would be more swimming even without breakwater protection if the rocks were covered with sand although the hazards of the rip current would remain. Third, they do not recognize the direct negative effects of the reduction of surfing that would result from the destruction of the southwestern surfing site under alternative 1, and the elimination of surfing that would result from the destruction of both surfing sites under alternative 2 and the recommended plan. Fourth they do not recognize the spectator benefits from the surfing, reinforced as they may be by the ancient tradition. Fifth, they do not recognize the value of the akule habitat that would apparently be destroyed by the breakwater. Finally, they do not recognize possible environmental detriments the quarrying of the breakwater rock.

The effects of correcting the omissions and eliminating the uncertainties noted are uncertain, but it seems probable that the net benefits and cost/benefit

ratios of the various project alternatives, and particularly the proposed plan would be reduced. It is possible that the basic plan, which would be the lowest in cost would be found also to have highest net benefits and cost/benefit ratio.

Additional alternatives

A number of alternatives to the proposed Kaimu beach project can be pointed out that have not been considered in the Corps Report and that appear worthy of consideration.

The simplest and cheapest, and not necessarily the least satisfactory, is to let nature take its course. The beach recession will continue, it is true, but the rate of recession should decrease as the sand is more and more protected by rock. The upper part of the beach face should continue to have essentially the same width as at present. More coconut trees will be lost and the swimming opportunities will be even more restricted than at present. The fishing, surfing, and surf watching opportunities will be unimpaired. The beach will remain a natural one. Perhaps most important, the options for future changes in plan will be least constrained under this alternative.

An alternative to the provision for swimming at Kaimu is the provision of swimming elsewhere on the southeast Puna coast, either at a natural cove, where the sand would have to be protected by an artificial breakwater, or in an artificial excavation in low land behind a lava ridge that would be left as the breakwater. It is unlikely that an alternative site would share the advantages that the proposed enlarged Kaimu beach would have of proximity to the existing County park, but, of course, parks could be created at the alternative sites. Proximity to the proposed resort development is also unlikely, and resort developments at alternative sites would probably not capture the combination of scenic beauty, archaeological value, and tradition that is present in the Kaimu-Kalapana area. A possible but unevaluated site that might retain all of the advantages in large measure would be the narrow beach and lava reef area fronting the dunes at Kalapana.

It must be admitted, of course, that the surfing opportunities could probably be provided at alternative sites as well, by the construction of artificial reefs. With the substitution of alternative sites, however, the continuance of the surfing tradition at Kaimu would be lost, and another site so beautiful would be difficult to find.

If a beach is to be created with breakwater protection at Kaimu, or elsewhere, an alternative to the harsh, brown cinders from the Kaakepa cone could be the well-rounded black dune sand from Kalapana. This sand, because of its fineness, would be less stable than that proposed for use, but the greater rates of loss would be offset by the easy availability of material for replenishment. The dune sand would probably be unsatisfactory for use unless there were a breakwater or some other means of protection of the beach.

The removal of the sand from the dunes would very likely be esthetically detrimental and might reduce significantly the protection afforded by the dunes against tsunami inundation. The possibilities of additional alternative sources of sand in offshore deposits beyond the range of the search conducted by the Corps seems worthy of investigation.

Alternatives to conventional breakwaters as means for protecting the present beach remnants at Kaimu or an enlarged beach there also appear worthy of investigation.

The above alternatives seem, from our general knowledge of the area to be reasonably likely to prove feasible. Each, however, would have to be examined more thoroughly to determine its feasibility. Other alternatives worthy of examination might perhaps be identified.

Quite possibly some of these alternatives have already been investigated by the Corps of Engineers. If so it would seem appropriate that these be identified and that their benefits and detriments be discussed to an extent sufficient to indicate whether or not they merit further consideration.

It seems quite possible that an alternative or combination of alternatives would provide additional opportunities for swimming and for beach park recreation, and minimize the losses of surfing, fishing and beauty, and such values as attached to these uses by reason of traditional, historical, and scientific significance and novelty, with a greater net benefit and a greater cost/benefit ratio than the alternatives proposed at Kaimu alone. This possibility seems sufficiently great to warrant thorough consideration of all alternatives before a commitment is made to the recommended plan at Kaimu.

Because the color and texture of the sand from Kaakepa Cone seems likely to be an important consideration, it would seem desirable at least to spread a sample on the beach for comparison with the natural sand. To make the test significant the sample would have to be representative of what could practicably be mined and screened.

Additional remarks

We do not want our discussion of deficiencies in the rationale for the Kaimu beach plan, as presented in the official documentation, to be interpreted as an indication that we are not appreciative of the work that has been done. Coastal engineering is at least as much an art as an exact science. This discipline has been skillfully applied in the development of the plans presented. However, the results of coastal modifications guided by those most expert in the field often indicate the limitations of the art. The recognition of these limitations should lead us to give very careful consideration to the premises on which proposals for coastal modifications are based, the detriments that are likely to be associated with the modifications, and the full range of alternative means for achieving the benefits that are desired, before we commit ourselves to essentially irreversible changes.

The evidence available in the Corps Report does not indicate that such full and careful consideration has yet been given to the proposal for alterations of Kaimu Beach.

The evidence available to us indicates that additional studies are in order particularly to evaluate some of the detriments associated with the recommended plan for alterations of Kaimu Beach and to identify and evaluate alternatives that might produce the benefits of the plan with less detriments.

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Appendix 1

JOHN A. BURNS
GOVERNOR OF HAWAII

DIVISIONS:
CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
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NATURAL AREA RESERVES SYSTEM COMMISSION

20 March 1972

MEMORANDUM TO: Dr. Doak Cox, U.H. Environmental Center

FROM: Steven L. Montgomery, State Natural Areas Specialist

SUBJECT: The Natural Area Reserves program and its relation to the proposed Kaimu Beach Breakwater

In 1970, the State Legislature and the Governor enacted a measure which provided for a Natural Area Reserves Sytem Commission. The first section of Act 139 instructs the Commission to establish a state-wide program for the preservation "in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawaii."

The Act states further that unique natural resources, such as geological and volcanological features are highly vulnerable to loss by the growth of population and technology and that these unique natural assets should be protected and preserved.

After the appointment by the Governor of the six Commission members in December 1970, the first responsibility was to develop a set of criteria for selecting the Reserves as was instructed by the Act. Then, attention was focused on the preparation of a comprehensive, long-range plan, which would assure that every ecosystem type and geologic feature was included and that priorities were assigned.

As part of its preliminary survey of geological features, the Commission has used a listing compiled by several authorities in the field of Hawaiian geology. The Kaimu Black Sand Beach is designated as a geologic feature meriting intensive consideration for protection of its natural state from any sort of development. We are aware also that it has been previously proposed for National Natural Landmark Status.

The Natural Area Reserves System Commission therefore issues a strong request that no breakwater construction be authorized until the Commission has concluded its survey of the State's geologic features. Perhaps a comparable beach will be located elsewhere, but until that time, the Commission must oppose any development plans that would alter the influence of natural forces. The proposed breakwater certainly would not be compatible with the beach's status as a Natural Area Reserve.

Please keep us apprised on this matter.

Steven L. Montgomery

Steven L. Montgomery

slm:pc